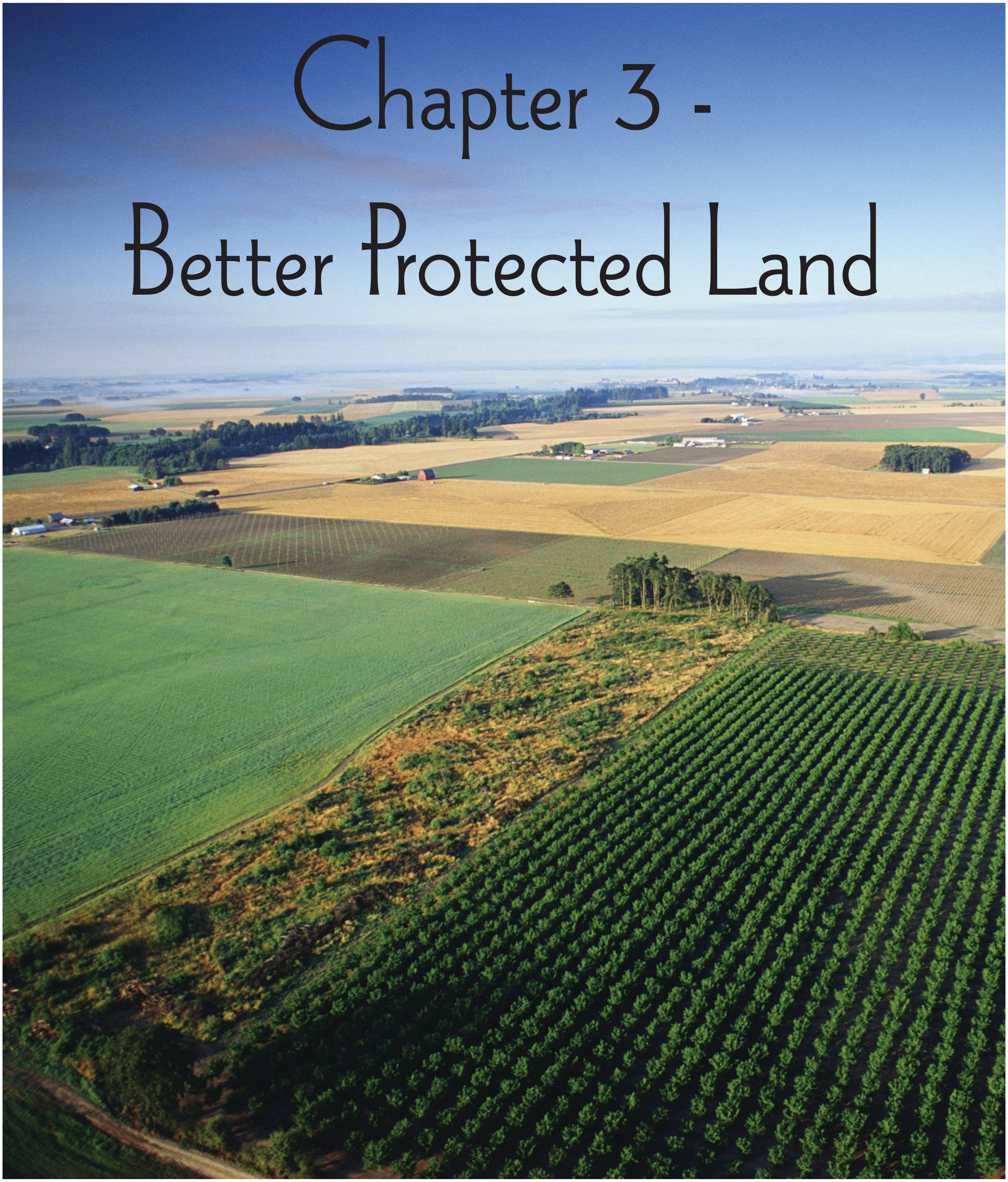
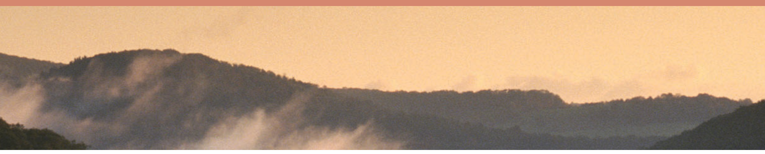
Chapter 3 - Better Protected Land

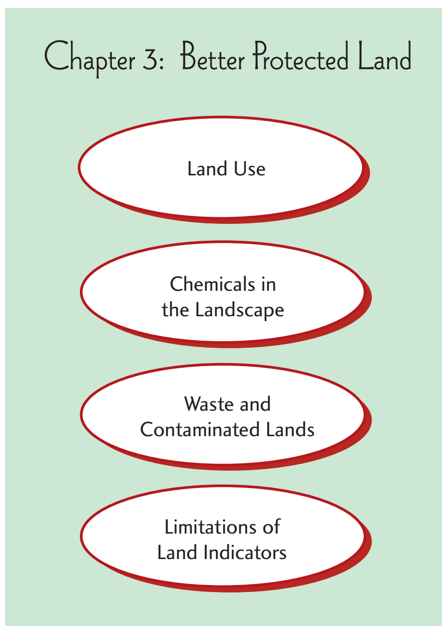




Introduction

The United States is a nation rich in land resources. The land provides the foundation on which communities are built, and from which food, shelter, and other essentials are obtained. Vast acreages not only provide habitat for hundreds of thousands of species, but also support agricultural activities, timber production, and mineral and energy extraction. In addition, diverse landscapes provide numerous opportunities for recreation and aesthetic enjoyment, including hiking, bird watching, gardening, camping, and skiing.

Much like air and water, land is a resource that must be carefully managed and protected. What happens on the land can affect not only land itself, but air and water as well, with potential consequences for human and ecological health. Protecting land resources means ensuring that lands meet current needs and support healthy communities and ecosystems. To this end, EPA's land protection activities focus on the prevention, management, control, and cleanup of various substances that are released to or used on land, such as toxic chemicals, pesticides, fertilizers, and wastes. Other government agencies, notably the U.S. Department of the Interior and the U.S. Department of Agriculture (USDA) at the federal level, manage land for natural resource and conservation purposes. Additionally, cities and counties adopt and implement land use laws and regulations, overseen in some cases by the states.



This chapter examines critical questions about aspects of land use, chemical and waste applications, and land contamination: How much land is being used for various purposes? How has this use changed over time? How much waste is generated, how has this changed, and how is the waste managed or disposed of? What is the extent of land contamination? The answers help to set a baseline against which to measure the effects of land practices on the condition of human health and ecosystems. The chapter presents available national-level data on these questions, and identifies gaps where the data are limited.

Land Use

The U.S. landscape has changed over the past 400 years through extensive use in meeting human needs for food and shelter, economic and energy development, and recreation. Before European settlers came to this country, the more than 2 billion acres of landscape consisted of forests, grasslands, deserts, shrublands, and wetlands. Today, 98 million acres are considered developed lands supporting residential, commercial, industrial, and transportation uses; 377 million acres are used specifically to produce crops; and 832 million acres are considered grazing lands.[1,2]

The federal government manages nearly 28 percent of the nation's lands, or 630 million acres, mostly in the western U.S. and Alaska.[3] Federal management responsibilities are distributed among several agencies, including the USDA Forest Service, the Bureau of Land Management, the National Park Service, the U.S. Fish and Wildlife Service, and the U.S. Department of Defense. State and local governments manage another 198 million acres.[4,5] The more than 828 million acres of publicly managed lands support various public purposes, such as recreational uses, the production of specific commodities, grazing for cattle and sheep, mineral exploration and development, and timber harvesting.[6,7,8] In many parts of the country, public land provides highly valued open space.

Land Use Indicators

Extent of developed lands

Extent of urban and suburban lands

Extent of agricultural land uses

Extent of grasslands and shrublands

Extent of forest area, ownership, and management

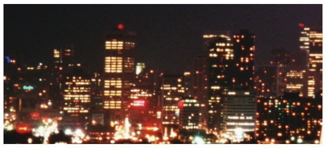
More than 4 percent of the nation is designated as wilderness, and millions of other acres are protected in national parks, state parks, wildlife refuges, or other classifications of reserved land. Of the 106 million acres of land now designated as federal wilderness, more than half are in Alaska.[9] Such protected lands provide recreational opportunities, open space, wildlife habitat, and watershed protection.

More than 1.4 billion acres of private and tribal land are managed in the interests of their owners, with various land use constraints imposed by zoning and other regulations.[10,11] Although both private and public landowners may use their lands for similar purposes, such as harvesting timber and raising livestock, private lands are more likely to be developed and used for crop production than those under public ownership. Many levels of government regulate land use, with widely varying practices, creating challenges in understanding national patterns of land use.

Another important land use, but one for which it is not possible to identify how much land is used, is land managed for energy production and other forms of mining. There are almost 1,900 producing coal mines, the majority of them surface mines in western states and underground mines in Appalachia. There are also nearly 2,000 other mines and 534,000 oil wells across the country. The extent of land that those activities affect is not known, but some of the results of mining are described in the chemicals and waste discussions in this chapter.[12]

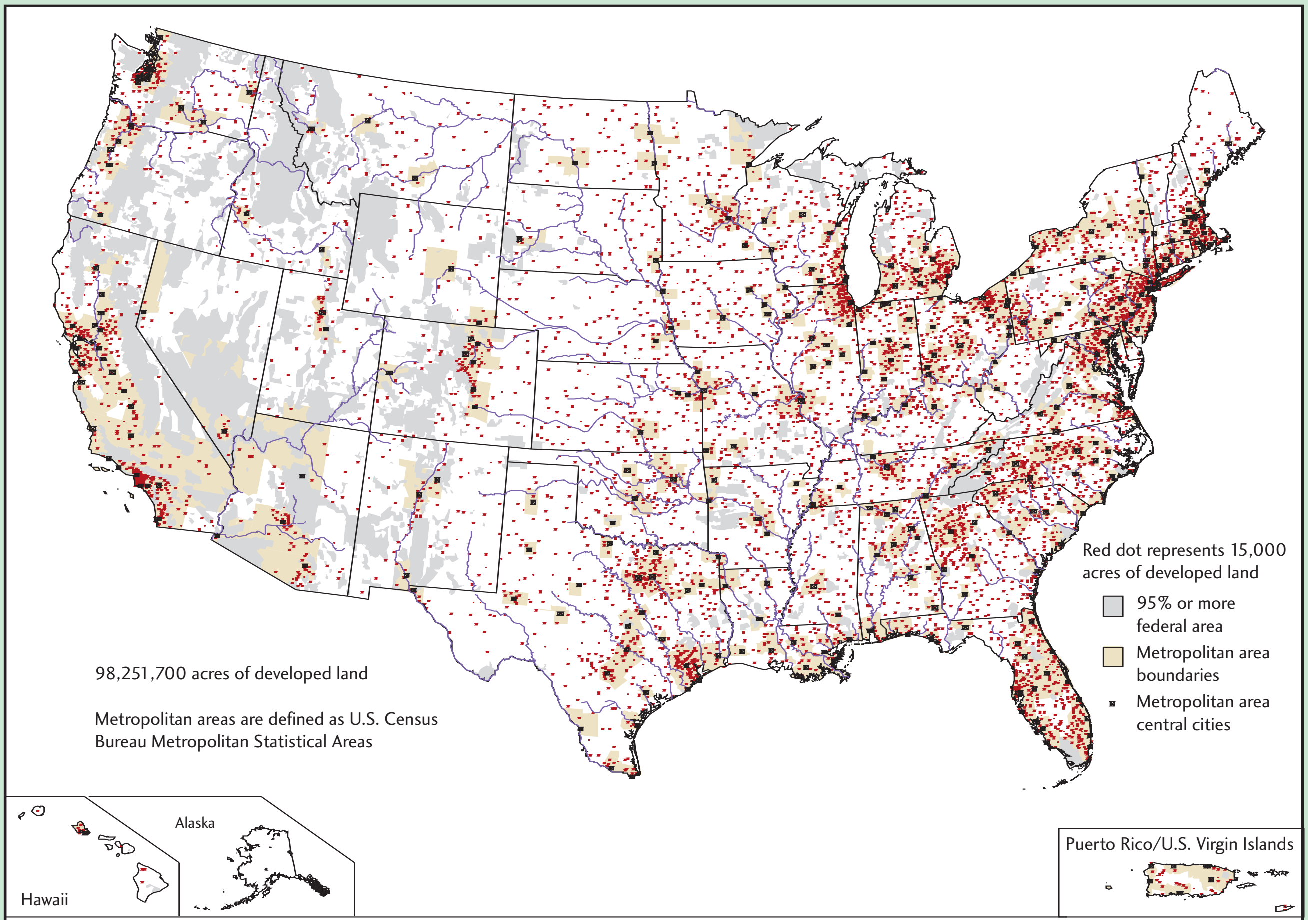
The following questions focus primarily on the extent of various land uses. Extent is important because it affects habitat availability for all species, including humans. Extent of land cover and land use represent two different concepts and both are discussed. Land cover is essentially what can be seen on the land—the vegetation or other physical characteristics—while land use describes how a piece of land is being managed by humans. In some cases, land uses can be determined by cover types (e.g., the presence of housing indicates residential land use), but often more information is needed for those uses that are not visible (e.g., lands leased for mining, "reserved" forest land, "grazing rights" on shrublands). Extent of uses and cover types is additionally complicated because there are numerous varying estimates of actual amounts due to different terminology, definitions, and approaches to estimation. Within the discussion of each question, those variations are explored. The importance of extent is discussed in more detail in Chapter 5 – Ecological Condition.

What is the extent of developed lands?



The majority of Americans live in areas or transport themselves on lands that are considered to be "developed land." Estimates of the actual amount of developed land vary depending on definitions of "developed" and differing assessment techniques.[13] The USDA Natural Resources Conservation Service's National Resources Inventory (NRI) estimated that there were approximately 98 million acres of developed land in the United States in 1997 (Exhibit 3-1).[14] That represents 4.3 percent of the nation's total land area, up from 3.2 percent in 1982.[15] Between 1982 and 1997, approximately 25 million acres of land, primarily forest and cropland, were converted to developed uses. The pace of land development in the 1990s was more than 1.5 times that of the 1980s.[16] Since the middle of the last century, the number of Americans living in U.S. Census Bureau-defined urban areas increased from 64 percent to 79 percent of the total population.[17] Urban and suburban ecosystems represent a subset of developed lands and include highly urbanized areas and surrounding suburbs, and developed outlying areas greater than 270 acres in size. Estimates are that there were approximately 32 million acres of urban and suburban lands in 1992.[18]

Exhibit 3-1: Extent of non-federal developed land, 1997

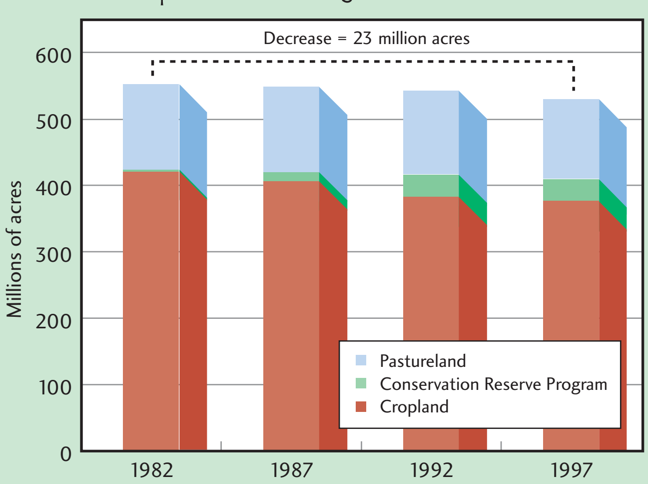


Source: USDA, Natural Resources Conservation Service. National Resources Inventory, 1997, revised December 2000: Acres of Developed Land, 1997. 2000. (January 2003; *http://www.nrcs.usda.gov/technical/land/meta/m4974.html*).

What is the extent of farmlands?

Farmlands are lands used for growing crops and producing forage, as well as the lands that contribute to those uses, such as forested windbreaks or farmsteads. Currently, there are no accurate estimates of the extent of farmland. Different components of farmland can be identified, including approximately 377 million acres of non-federal lands that are used to grow crops and 120 million acres of pastureland managed to produce forage for livestock.[19] Most of these croplands and pasturelands are privately owned. Another 712 million acres of both private and public lands may support grazing for livestock production, but these lands are not specifically seeded or fertilized and are normally not considered part of farmlands.[20,21] Lands used for agricultural production show constant shifts in the uses among crop, pasture, range, and forest to meet production needs, implement rotations of land in and out of cultivation, and maintain and sustain soil resources. Within those shifts, however, trends indicate that the amount of cropland, rangeland, and pastureland in the U.S. has gradually decreased because of lower U.S. exports of grain, improvements in agricultural productivity and efficiency, and conversion of agricultural lands to development near growing population centers.[22] Between 1982 and 1997, cropland acreage decreased by 10.4 percent (44 million acre decrease) and pastureland acreage by 9.1 percent (12 million acre decrease) (Exhibit 3-2).[23] In that same timeframe, however, 32.7 million acres consisting primarily of croplands were enrolled in the Conservation Reserve Program (CRP), a voluntary program that encourages farmers to set aside agricultural lands for conservation purposes.[24]

Exhibit 3-2: Change in cropland, CRP land, and pastureland acreage, 1982-1997



Source: USDA, National Resources Conservation Service. *Summary Report 1997 National Resources Inventory (revised December 2000)*. 2000.

What is the extent of grasslands and shrublands?

As of 1992, the ecosystem of grasslands and shrublands occupied about 861 million acres in the lower 48 states and 205 million acres in Alaska, for a total of 1.066 billion acres (excluding Hawaii), or about 47 percent of the U.S.[25] That area includes not only the grasslands and shrublands of the West but coastal meadows, grasslands and shrubs in Florida, mountain meadows, hot and cold deserts, and tundra. It also includes more-managed grasslands and agricultural lands that are often classified as rangelands and pasturelands. One of the challenges in determining the extent of this ecosystem is that grasslands and shrublands can be used for grazing and are often counted as agricultural lands.

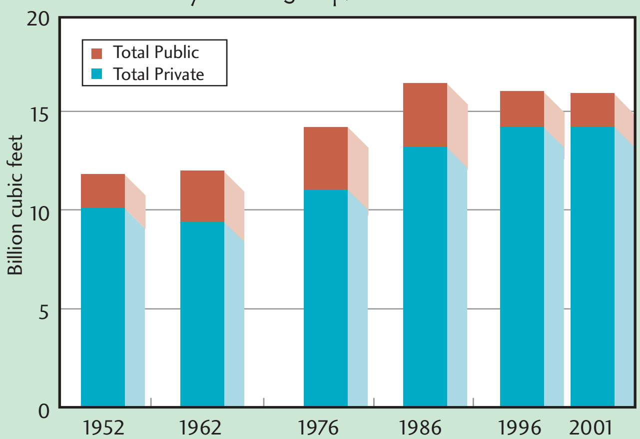
The State of the Nation's Ecosystems: Measuring the Lands, Waters, and Living Resources of the United States concludes that no consistent, nationwide data are available on the change in acreage of grasslands and shrublands. Researchers have estimated that there were between 900 million and 1 billion acres of grasslands and shrublands in the lower 48 states before European settlement. On the basis of that estimate, between 40 million and 140 million acres had been converted to other uses by 1992.[26]

What is the extent of forest lands?

In 2001, forests covered about one-third of the national land area, approximately 749 million acres.[27,28] It is estimated that in 1630, 1.045 billion acres of forest land existed in what was to become the land area of the U.S. Nearly 25 percent of these lands were cleared by the early 1900s, leaving 759 million acres of forest land in 1907. Since that time the total amount of forest land nationwide, while changing regionally has remained relatively stable, with an increase of 2 million acres between 1997 and 1999.[29]

Most forested lands are managed for a combination of uses, including recreation, timber production, grazing, and mining. Approximately 10 percent of the nation's forests is "reserved" through designations such as national parks or wilderness areas, and 9 percent supports private industrial (major timber management companies) timber production.[30] In 2001, the USDA Forest Service considered more than 503 million acres of both private and public forests "timberlands," or available for harvest. From 1976 to 2001, public land harvest nationwide dropped nearly 47 percent to less than 2 billion cubic feet annually. In the same timeframe, private land harvest increased by almost 29 percent to 14 billion cubic feet annually (Exhibit 3-3).[31] Private forests are being converted to developed land uses faster than any other land type.[32] (Chapter 5 – Ecological Condition contains a more detailed discussion of forest land condition.)

Exhibit 3-3: Timber removals in the United States by owner group, 1952-2001



Source: USDA, Forest Service. Draft Resource Planning Act Assessment Tables. May 3, 2002 (updated August 12, 2002). (September 2003; *http://www.ncrs.fs.fed.us/4801/FIADB/rpa_tabler/Draft_RPA_2002_Forest_Resource_Tables.pdf*).

What human health effects are associated with land use?

Land development patterns have direct effects on air and water quality, which can then affect human health. The increased concentration of air pollutants in developed areas can exacerbate human health problems such as asthma. Increased storm water runoff from impervious surfaces can increase the flow of polluted runoff into surrounding waterbodies that residents may rely on for drinking and recreation. Development patterns can affect quality of life by limiting recreational opportunities, decreasing open space and wildlife habitat, and increasing vehicle miles traveled and the amount of time spent on roads. And, as discussed later in this chapter, agricultural land uses may expose humans to dust and various chemicals.

What ecological effects are associated with land use?

Land use and land management practices change the landscape in many ways that can have direct and indirect—as well as positive and negative—ecological effects. One direct effect is the conversion of one type of use to a more human-oriented land use, such as developed land or agriculture. Examples of indirect effects may include changes in runoff patterns or soil erosion.

Land development affects water quality and quantity by creating hard surfaces such as roads, structures, and parking lots. Such impervious surfaces limit the natural soil filtering process, change runoff patterns, contribute to floods, and potentially contribute to the effects of droughts due to lower water tables. Land development also creates "heat islands," domes of warmer air over urban and suburban areas caused by the loss of the cooling effects of trees and shrubs and the absorption of more heat by pavement, buildings, and other sources. Some agricultural practices can degrade ecological condition, such as livestock grazing, which can damage streamside vegetation and contribute nutrients to ecosystems that then enter waterbodies. Forest practices can affect water quality when trees are removed along streams or on steep slopes, causing erosion, stream sedimentation, increased water temperatures (from loss of shade), and loss of fish habitat. Tree planting can have positive ecological effects by lowering stream temperatures and improving fish habitat. Other chapters contain further discussion of the effects of land development and agricultural and forest uses on ecosystems and water quality (see Chapter 2 – Purer Water; and Chapter 5 – Ecological Condition).

Land use can also have indirect effects on air quality. Patterns of dispersed land development increase the number of miles

Measuring Impervious Surfaces

One effect of land development is the creation of impervious surfaces—areas, for example, with pavement or buildings, which restrict or prevent the infiltration of water into underlying soil. Research has shown that increasing the amount of impervious surfaces within watersheds can degrade streams and affect the health of aquatic ecosystems. Some aquatic species may be affected when impervious surfaces constitute as little as 2 percent of a watershed's area; others may be affected when impervious surface area is 10 to 12 percent. By preventing the processing of pollutants through soils, impervious surfaces help channel pollutants directly into waterways. Estimates of impervious areas have been developed based on many approaches, including the use of remotely sensed satellite imagery such as the National Land Cover Dataset (NLCD), assessments of population and road density, and zoning delineations. Over the last several years, EPA researchers analyzed 1,624 watersheds in Georgia using two different approaches. In the first approach, three different data sets (population density from census block-level data, commercial/industrial and quarrying/mining land cover categories from the NLCD, and major highway and interstate digital data coverage) were integrated for analysis. The second approach applied assumptions about percentage of imperviousness to various classes of NLCD data. The NLCD-only approach showed that 69 of the Georgia watersheds had greater than 10 percent total impervious area, while the integrated analysis identified 80. The NLCD-only approach identified 76 watersheds in the 5 to 10 percent impervious range, whereas the integrated analysis showed 117 watersheds. The results indicate that the NLCD-only approach provides a rapid-assessment tool for identifying currently urbanized and impaired watersheds (more than 10 percent imperviousness), but it underestimates potentially vulnerable watersheds that may suffer impairment in the near future (currently 5 to 10 percent imperviousness).[33,34]

driven by commuters. Agricultural land uses contribute to wind erosion and dust in many areas of the country.

Certain land uses and practices, such as land conversion, overgrazing, excess fertilization, and use of agricultural chemicals, can enhance the growth of invasive plants.[35] Additionally, failure to manage invasive species can lead to major threats to native ecosystems.[36]

Land practices related to development, timber harvest, and agriculture can affect soil quality both positively and negatively. Some agricultural practices such as organic farming, creation of buffer strips in riparian areas, and precision pesticide and fertilizer application technologies can improve land conditions. Other practices may negatively affect soil quality by promoting soil compaction and erosion. Soil erosion can have several major effects on ecosystems. Sediment is the greatest pollutant in aquatic ecosystems, by both mass and volume, and soil erosion and transport are the source.[37] Although rates of erosion declined between 1982 and 1997 by about 1.4 tons per acre, more than one-quarter of all croplands still suffer excessive water and wind erosion.[38,39] (Excessive is defined as exceeding "tolerable" rates as defined by USDA Natural Resources Conservation Service models).[40]

Land conversion and land management practices also have significant effects on sensitive areas, such as wetlands, coastal areas, and the banks of streams, rivers, and lakes. According to USDA estimates, most wetland conversion over the past 15 years, particularly in the southern and eastern parts of the country, has been due to land development.[41] (See Chapter 2 – Purer Water for an in-depth discussion of wetlands, their significance, and loss.)

Chemicals in the Landscape

The nation's commerce depends greatly upon the development and use of chemical products, and over the past 50 years, the use of such chemicals has increased significantly. The Toxic Substances Control Act chemical inventory now identifies more than 76,000 chemicals currently or recently used in the country. Nearly 10,000 of those, excluding inorganic polymers, microorganisms, naturally occurring substances, and non-isolated intermediaries, are produced or imported in quantities greater than 10,000 pounds per year; for about 3,100 chemicals, the quantities exceed 1 million pounds per year. Associated annual production and import volumes increased by 570 billion pounds (9.3 percent) to 6.7 trillion pounds between 1990 and 1998.[42] Commercial and industrial processes such as mining, manufacturing, and electrical generation all use and release chemicals. Pesticides are used in homes, yards, factories, and office buildings and, most frequently, to support agricultural production, where they have contributed to an increase in agricultural productivity levels over the past 50 years. Fertilizers, used to supplement soils for enhanced plant growth, have also contributed to those productivity increases.

Chemicals in the Landscape Indicators

Quantity and type of toxic substances released and managed

Agricultural pesticide use

Fertilizer use

Pesticide residues in food

Potential pesticide runoff from farm fields

Risk of nitrogen export

Risk of phosphorous export

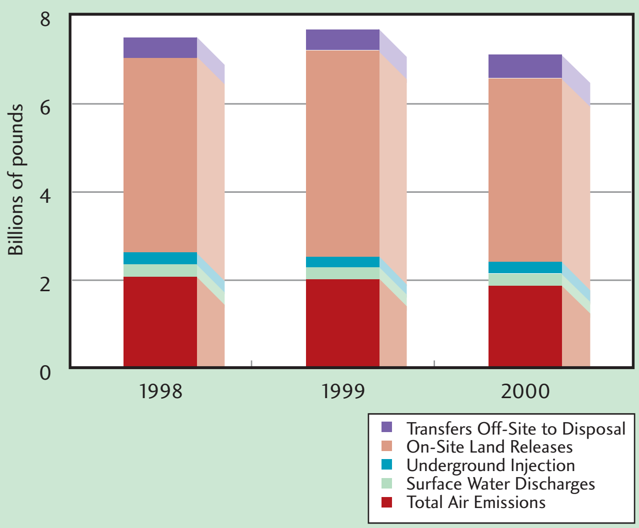
The use and release to the environment of chemicals have created a range of challenges for protecting human health and the environment. Toxic chemicals, including some pesticides, can lead to a variety of acute or chronic health problems, and excess fertilizers carried in runoff may contribute nutrients to aquatic ecosystems that harm water quality and aquatic life.

How much and what types of toxic substances are released into the environment?

Many industries release toxic substances into the air, soil, and water through their manufacturing and production activities. Under the Emergency Planning and Community Right-to-Know Act of 1986 and the Pollution Prevention Act of 1990, facilities are required to calculate and report to EPA and states their releases of more than 650 toxic chemicals and chemical compounds. EPA makes these toxics release data available to the public through the Toxics Release Inventory (TRI). In 2000, total TRI releases reached 7 billion pounds. Of these releases, 58 percent were to land, 27 percent were to air, 4 percent each were to water and underground injection at the generating facility, and 7 percent were chemicals disposed of off-site to land or underground injection. Between 1998 and 2000, toxic releases decreased overall by about 409 million pounds, or 5.5 percent. Of that total, releases to land decreased by approximately 276 million pounds (Exhibit 3-4).[43] Of the original set of chemicals from industries that have reported consistently since 1988, total on- and off-site releases decreased 48 percent between 1988 and 2000, a reduction of 1.55 billion pounds.[44]

Some of the releases reported in the TRI include chemicals that are managed under EPA regulations. For example, the above figures for total releases in the TRI include chemicals in waste disposed of in hazardous waste disposal units regulated under Subtitle C of the Resource Conservation and Recovery Act (RCRA), whether at the generating facility or after being transferred to another facility. Approximately 206 million pounds of toxic chemicals in waste were disposed of in RCRA Subtitle C facilities in 2000, which corresponds to approximately 2.9 percent of total TRI releases in 2000.[45] In addi-

Exhibit 3-4: Total Toxics Release Inventory (TRI) releases across industry, 1998–2000



Source: EPA, Office of Environmental Information. *2000 Toxics Release Inventory (TRI) Public Data Release Report*. May 2002.

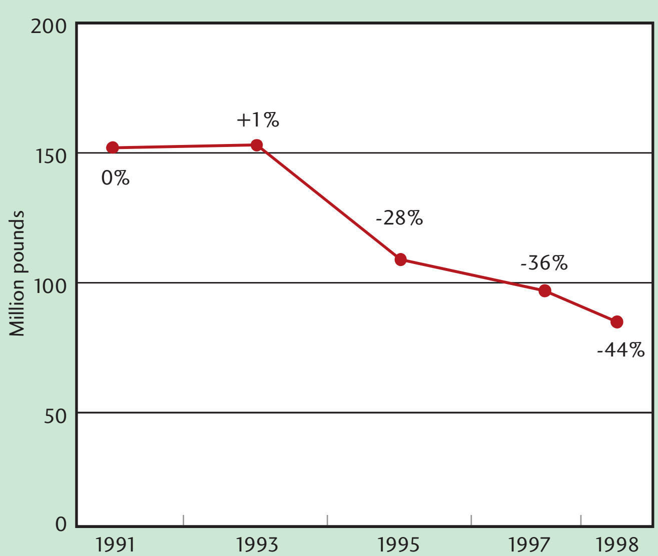
tion to the 7 billion pounds of toxic chemicals released in 2000, 31 billion pounds of toxic chemicals were managed and transferred for treatment (50 percent), recycling (39 percent), and burning for energy recovery (11 percent). The total amount of toxic chemicals managed and transferred between 1998 and 2000 increased by almost 29 percent, a net increase of 8.4 billion pounds.[46] For the past few years, EPA has tracked three metals—lead, mercury, and cadmium—and 27 organic chemicals, which were identified as the highest priorities for waste minimization. The Agency uses those waste minimization priority chemicals (WMPC) to measure the total weight of particularly toxic chemicals going to disposal. Trend data are available for 17 of the 30 WMPCs and show that releases of those 17 have been steadily declining since 1993 (Exhibit 3-5). Overall, between 1991 and 1998, there was a 44 percent reduction in WMPC quantities generated in industrial and hazardous waste.[47]

Persistent bioaccumulative toxic (PBT) chemicals, including dioxins, lead, mercury, and PCBs, are tracked because they persist and accumulate in the environment. In 2000, PBTs represented 12.1 million pounds (less than 1 percent) of the released chemicals that TRI tracks.[48] Although they constitute a fraction of overall toxic releases, PBTs are significant even in small quantities, given the chronic risks they pose to ecosystems and humans through bioaccumulation.

What are the volume, distribution, and extent of pesticide and fertilizer use?

Pesticides are substances or mixtures used to destroy or repel various pests, including insects, animals, plants, and microorganisms. EPA's most recent *Pesticide Industry Sales and Usage* report shows that annual use of pesticides for all purposes

Exhibit 3-5: Trends in Toxics Release Inventory (TRI) waste minimization priority chemicals (WMPC), 1991-1998



Source: EPA, Office of Solid Waste and Emergency Response. *Waste Minimization Trends Report (1991-1998)*. September 2002.

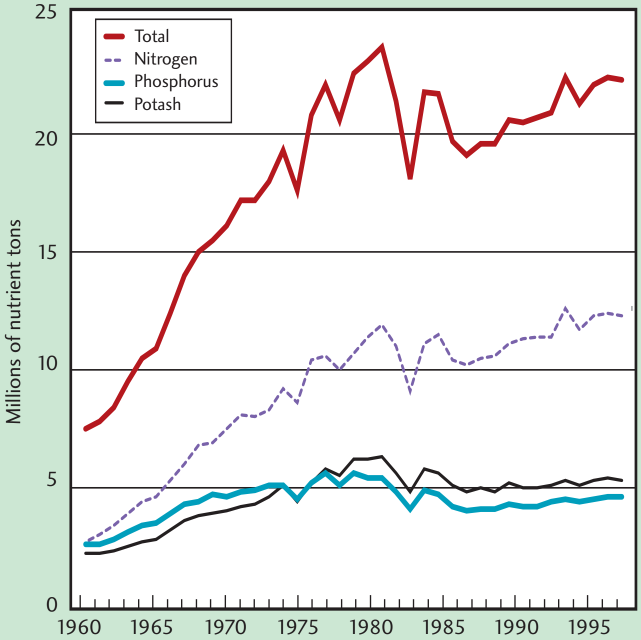
declined by about 15 percent between 1980 and 1999.[49] This decline has not been steady, with pesticide use higher in 1999 than it was in the early 1990s. Excluding chlorine used for disinfection, the largest use of pesticides is in agricultural production, and that use fluctuates, depending on a number of factors such as weather or type of crop. According to the National Center for Food and Agricultural Policy (NCFAP), a private, non-profit research organization, use of agricultural pesticides increased between 1992 and 1997 from 892 million to 985 million pounds.[50] The recent EPA report shows a similar increase in use of all pesticides in this same timeframe, with a leveling of use between 1997 and 1999.[51]

Approximately half of those pesticides are herbicides used to control weeds that limit or inhibit the growth of a desired crop. Pesticides are also used in smaller quantities in rights-of-way, businesses, and home lawns and gardens. Based on EPA's national pesticide sales estimates, industrial, commercial, and governmental pesticide applications—many of which occur in urban environments—totaled 148 million pounds in 1999. Home and garden pesticide use was estimated to be 140 million pounds.[52]

The use of insecticides, which as a class tend to be the pesticides most acutely toxic to humans and wildlife, significantly declined between 1997 and 2001. The number of individual chemical treatments per acre (acre-treatments) for insecticides labeled "danger for humans" decreased by 43 percent. In that same period, acre-treatments for insecticides labeled "extremely or highly toxic to birds" declined by 50 percent, and acre-treatments of those labeled "extremely or highly toxic to aquatic organisms" dropped by 23 percent.[53]

The use of nitrogen, phosphorus, and potash, the most prevalent fertilizer supplements in commercial farming, rose from 7.5 million nutrient tons (tons of a chemical nutrient in a fertilizer mixture) in 1961 to nearly 24 million nutrient tons in 1981. Exhibit 3-6 displays trends in the use of fertilizer over the past 40 years. Although aggregate use dipped in 1983, it increased most recently between 1996 and 1998 to more than 22 million nutrient tons.[54] Use of most major fertilizers is concentrated on croplands in the Midwest.[55] (Chapter 2 – Purer Water discusses some of the effects of fertilizer use on water quality.)

Exhibit 3-6: Use of fertilizer, 1960-1998



Source: Daberkow, S. et al. *Agricultural Resources and Environmental Indicators: Nutrient Use and Management.* February 2003.

What is the potential disposition of chemicals from land?

Chemicals and nutrients can move from their location of use or origin to a place in the environment where humans and other organisms can become exposed to them. People are exposed to chemicals in all aspects of their daily lives, through their clothing, use of everyday products, housing, automobiles, and buildings.

Pesticide residues on food are one way people can be exposed to pesticides. The U.S. Department of Agriculture's Pesticide Data Program (PDP) measures pesticide residue levels in fruits, vegetables, grains, meat, and dairy products from across the country, sampling different combinations of commodities each year. In 2000, PDP collected and analyzed a total of 10,907 samples: 8,912 fruits and vegetables, 178 rice, 716 peanut butter, and 1,101 poultry which originated from 38 States and 21 foreign countries. Approximately 80 percent of all samples were domestic, 19 percent were imported, and less than 1 percent was of unknown origin.[56]

The simple presence of detectable pesticide residues in foods should not be considered indicative of a potential health concern. The PDP uses analytical methods that are very sensitive and are capable of detecting extremely small (or "trace") quantities of pesticides that are orders of magnitude lower than those raising potential health concerns. Overall, approximately 42 percent of all samples contained no detectable pesticide residues, 22 percent contained a detectable residue of a single pesticide, and 35 percent contained detectable amounts of two or more pesticides. Testing found that no more than 1.4 percent of samples exceeded regulatory limits (also known as "tolerance levels"). Residues exceeding the pesticide tolerance level established by EPA for that food were detected in only 0.2 percent of all composite samples. Residues of other pesticides for which no tolerance level had been set by EPA for that food were found in 1.2 percent of all samples. These residues were generally at low concentrations and may be due to spray drift, crop rotations, or cross contamination at packing facilities. USDA reports all such exceedances to the Food and Drug Administration for further investigation and any needed follow-up.[57]

Pesticide and fertilizer runoff into surface and ground water can also expose humans and the environment to the effects of chemicals. Models that use data from the USDA NRI, the NCFAP, and other sources show that the highest potential for pesticide runoff is predominantly associated with the upper and lower Mississippi and Ohio River valleys.[58] Similarly, EPA has developed models based on land cover characteristics to assess the risk of nitrogen and phosphorus runoff into watersheds. Those studies also show that the areas with the highest risk for nitrogen and phosphorus runoff are concentrated in the midwestern states and other agricultural areas.[59] (See Chapter 5 – Ecological Condition for additional discussion of how nutrient runoff can affect the chemical characteristics of ecosystems.)

In addition to runoff, chemicals can enter land through pesticide "spray drift," the physical movement of a pesticide through air at the time of application, or soon thereafter, to any site other than that intended for application. Both modeling and incident reports indicate that spray drift is a route of disposition.[60]

What human health effects are associated with pesticides, fertilizers, and toxic substances?

Because they are designed to kill or harm living organisms, many pesticides pose some risk to humans, animals, and the environment. The risk of adverse health effects depends on how, where, how much, and how frequently pesticides are used; what happens after use; who is exposed; and how they are exposed. Human exposures to harmful levels of chemicals, such as organophosphates or organochlorine pesticides, can cause adverse neurological, developmental, and reproductive effects. A significant challenge lies, however, in correlating the existence of chemicals in the environment, either singly or in combination, with the health effects observed in a given population.

There are no nationwide pesticide surveillance systems to track exposure consistently, but several state and national pesticide surveillance systems do collect information on pesticide-related injuries and illness. Although those systems are not nationally comprehensive, their information provides a starting point for examining the health effects of pesticides.

Fertilizers are often applied in greater quantities than crops can absorb and end up in surface or ground water. Although fertilizers may not be inherently harmful, they can be linked to human health problems when excess nutrients cause algal blooms and eutrophication in waterbodies. Drinking ground water contaminated with runoff from some fertilizers can have severe or even fatal health effects, especially in infants and children (e.g., blue baby syndrome).[61]

The Toxic Exposure Surveillance System (TESS) contains information from poison control centers that report occurences of pesticide-related injury and illness. One finding from TESS data is that organophosphates are much more likely to cause post application symptoms than are other types of pesticides. In addition, the data show that in 2001, more than 100,000 people were sufficiently concerned about their actual exposure to pesticides to call their local poison control center. Estimates are that approximately 19 percent of the people who called developed symptoms as a result of their pesticide exposure. These symptoms included abdominal pain, diarrhea, vomiting, rash, blurred vision, irriatation to eyes or skin, headache, dizziness, coughing, and difficulty breathing. In addition, of the approximately 20,000 cases that were followed to determine medical outcome: 83 percent had a minor outcome, 15 percent had a moderate outcome (usually require treatment), and 1.5 percent had a major outcome (life-threating symptoms or residual disability).[62] Other studies of treated poisonings, not just from pesticides, have found that the poison control center data may capture only about 25 percent of all poisoning incidents.[63]

Health effects from exposure to toxic chemicals range from short-term acute effects to long-term chronic effects such as cancer or asbestosis. For example, as discussed in Chapter 4 – Human Health, despite major success in reducing exposure to lead, many children remain at risk of neurological damage through lead poisoning—primarily from contact with lead-based paint chips and lead-containing dust in their homes. In addition, EPA, along with other state and federal agencies that are responsible for protecting public health, pays special attention to PBTs and persistent organic pollutants, which do not easily break down and thus tend to accumulate in humans and other organisms. Such accumulation can lead to serious chronic health issues.[64]

What ecological effects are associated with pesticides, fertilizers, and toxic substances?

A number of ecological effects of direct chemical exposure on individual species have been identified. Reproductive failure in birds, for example, has been linked to organochlorine insecticides such as DDT, which are still present in the environment from past applications in the United States, as well as from current use in other parts of the world. Many pesticides are toxic to a variety of fish, bird, plant, and insect species. As a result, use—and especially misuse—of pesticides can, where exposures are of sufficient magnitude, cause significant loss of non-target species. Eliminating or limiting those exposures may have a beneficial effect. For example, the resurgence of the bald eagle population is thought to be the result, at least in part, of bans on various chemicals.[65]

Indirect environmental effects of pesticides and other chemicals on ecosystems are more complex and difficult to understand. As previously discussed, pesticides and nutrients run off from their point of application and are deposited in aquatic systems and sediments, where they may accumulate to levels that exceed water quality standards for specific chemicals. (The effects of runoff on the condition of aquatic systems are discussed in more detail in Chapter 2 – Purer Water.)

Contaminant Levels and Bald Eagles in Michigan

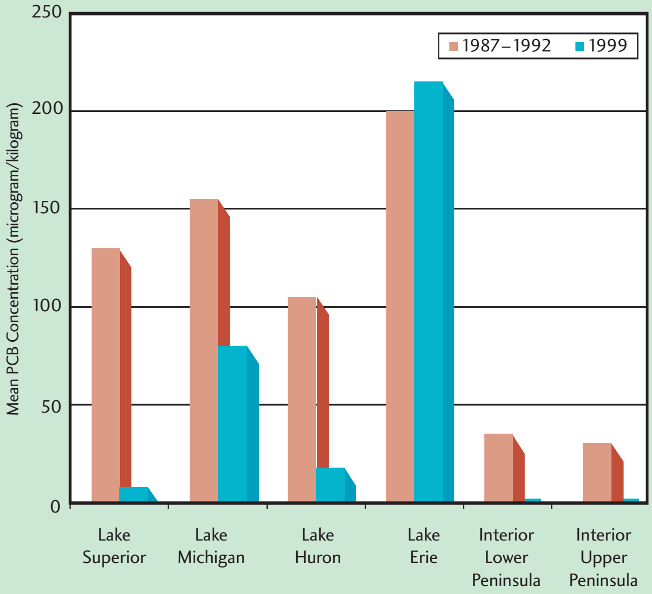
Bald eagles were significantly affected by contaminants in the environment in the early 1960s and 1970s. Now monitoring them can provide a gross indication of general contaminant levels in the environment. In 1999, a consortium of the Michigan Department of Environmental Quality, the U.S. Fish and Wildlife Service, and researchers from Michigan State University and Clemson University initiated a bald eagle contaminant-monitoring project. Ninety samples of blood and feathers were collected by non-lethal procedures from permanent inland nests, from nests in additional inland watersheds being assessed as part of the Michigan department's 5-year watershed assessment cycle, and from Great Lakes and connecting channel nests.

Exhibits 3-7 and 3-8 show changes in mean PCB levels and mean mercury levels, respectively, in bald eagles between the late 1980s and early 1990s, and in 1999. Specifically, PCB levels in the blood of bald eagles were dramatically lower in 1999 for inland nests and those in Lakes Superior, Michigan, and Huron. (Although Lake Erie did not show the same result, only one eagle was sampled there in 1999.) Similarly, mean mercury levels in bald eagle feathers declined in all geographic areas examined.

The Michigan Department of National Resources has also conducted an annual census of bald eagle nests in Michigan since 1961. The nests increased from 50 in 1961 to 366 in 2000. During that same time period, bald eagle productivity, as measured by the number of young fledged per nest, increased more than 50 percent.

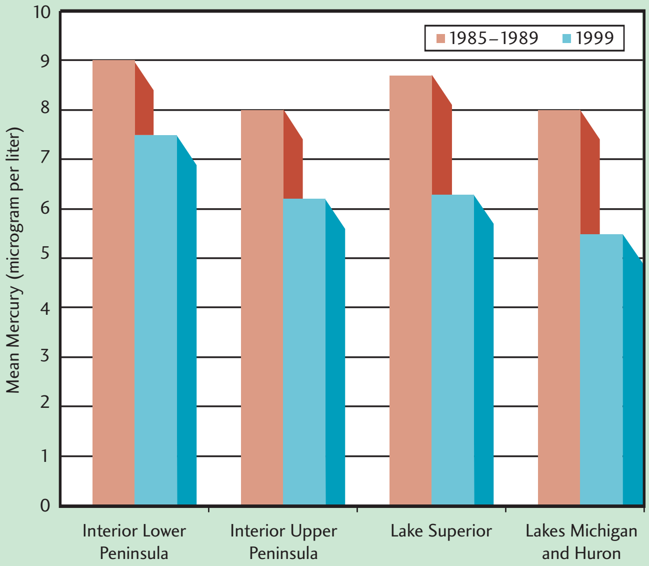
The contaminant and population measures demonstrate that levels of key environmental contaminants in bald eagles within the Great Lakes Region have declined through the 1990s, and that populations and productivity are increasing.[66]

Exhibit 3-7: Mean polychlorinated biphenyls (PCB) concentrations in nesting bald eagle feathers, 1987-1992 and 1999



Source: Michigan Department of Environmental Quality, Office of Special Environmental Projects. *State of Michigan's Environment 2001: First Biennial Report.* 2001.

Exhibit 3-8: Mean mercury levels in nesting bald eagle feathers, 1985-1989 and 1999



Source: Michigan Department of Environmental Quality, Office of Special Environmental Projects. *State of Michigan's Environment 2001: First Biennial Report.* 2001.

Waste and Contaminated Lands

"Waste" is broadly defined as unwanted material left over from manufacturing processes or refuse from places of human or animal habitation. Within that category are many types of waste, including municipal solid waste, hazardous waste, and radioactive waste, which have properties that may make them dangerous or capable of having a harmful effect on human health and the environment.[67] Waste and contaminated lands are particularly important to environmental health because they may expose land and living organisms to harmful material if they are not properly managed.

There have been major improvements in managing the nation's waste and in cleaning up contaminated sites. National, state, tribal, and local waste programs and policies aim to prevent pollution by reducing the generation of wastes at their source and by emphasizing prevention over management and subsequent disposal. Preventing pollution before it is generated and poses harm is often less costly than cleanup and remediation. Source reduction and recycling programs often can increase resource and energy efficiencies and thereby reduce pressures on the environment. When wastes are generated, EPA, state environmental programs, and local municipalities work to reduce the risk of exposures. If land is contaminated, cleanup programs address the sites to prevent human exposure and ground water contamination. Increased recycling protects land resources and extends the life span of disposal facilities.

Waste and Contaminated Lands Indicators

Quantity of municipal solid waste (MSW) generated and managed

Quantity of RCRA hazardous waste generated and managed

Quantity of radioactive waste generated and in inventory

Number and location of municipal solid waste (MSW) landfills

Number of RCRA hazardous waste management facilities

Number and location of Superfund national priority list sites

Number and location of RCRA corrective action sites

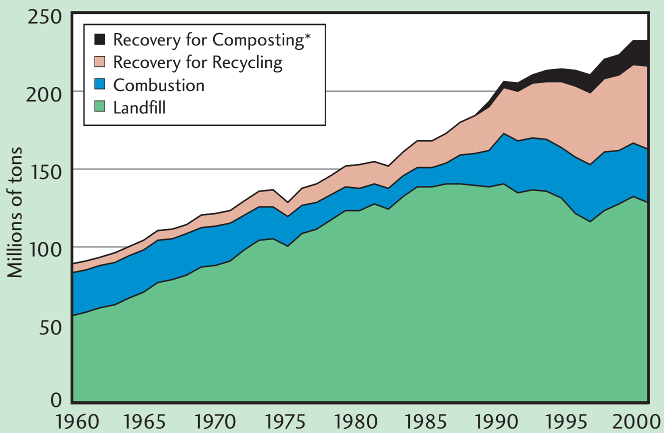
How much and what types of waste are generated and managed?

The types of waste generated range from yard clippings to highly concentrated hazardous waste. Only three types of waste—municipal solid waste (MSW), hazardous waste (as defined by the Resource Conservation and Recovery Act [RCRA]), and radioactive waste—are tracked with any consistency on a national basis. Other types of waste, for which no or very limited national data exist, are listed in the box, "Other Types of Waste," and are described in detail in Appendix B.

MSW, commonly known as trash or garbage, is one of the nation's most prevalent waste types. In 2000, the U.S. generated approximately 232 million tons of MSW, primarily in homes and workplaces—an increase of nearly 160 percent since 1960.[68] During that time, the population increased 56 percent, and gross domestic product increased nearly 300 percent.[69] In 2000, each person generated approximately 4.5 pounds of waste per day—or about 0.8 tons for the year—a per-capita generation increase from 2.7 pounds per day in 1960.[70] For the last decade, per capita generation has remained relatively constant, and the amount of MSW recovered (recycled or composted) increased more than 1,100 percent, from 5.6 million to 69.9 million tons in total (Exhibit 3-9).[71] Combustion (incineration) is also used to reduce the volume of waste before disposal. Approximately 33.7 million tons (14.5 percent) of MSW were combusted in 2000.[72] Of that amount, approximately 2.3 million tons were combusted for energy recovery—a process where energy is produced from waste combustion and made available for other uses.[73]

Exhibit 3-9: Municipal solid waste management, 1960-2000

(2000 total = 232 million tons)



*Composting of yard trimmings and food wastes. Does not include mixed MSW composting or backyard composting.

Source: EPA, Office of Solid Waste and Emergency Response. *Municipal Solid Waste in the United States: 2000 Facts and Figures*. June 2002.

The term "RCRA hazardous waste" applies to hazardous waste (waste that is ignitable, corrosive, reactive, or toxic) that is regulated under the RCRA. In 1999, EPA estimated that 20,000 businesses generating large quantities—more than 2,200 pounds each per month—of hazardous waste collectively generated 40 million tons of RCRA hazardous waste.[74] Comparisons of annual trends in hazardous waste generation are difficult because of changes in the types of data collected (e.g., exclusion of wastewater) over the past several years. But the amount of a specific set of priority toxic chemicals found in hazardous waste and tracked in the Toxics Release Inventory is declining, as previously discussed under "Chemicals in the Landscape." In 1999, approximately 69 percent of the RCRA hazardous waste was disposed of on land by one of four disposal methods: deep well/underground injection, landfill disposal, surface impoundment, or land treatment/application/farming.[75]

In 2000, approximately 600,000 cubic meters of different types of radioactive waste were generated, and approximately 700,000 cubic meters were in storage awaiting disposal.[76] By volume, the most prevalent types of radioactive waste are contaminated environmental media (i.e., soil, sediment, water, and sludge requiring cleanup or further assessment) and low-level waste. Both of these waste types typically have the lowest levels of radioactivity when measured by volume. Additional radioactive wastes in the form of spent nuclear fuel (2,467 metric tons of heavy metal) and high-level waste "glass logs" (1,201 canisters of vitrified high-level waste) are in storage awaiting long-term disposal.[77] Very small amounts of those wastes are still being generated. For example, less than 1 cubic meter of spent nuclear fuel was generated in 2000. The total amount of radioactive waste being generated is expected to drop over the next few decades as cleanup operations are completed.[78]

As previously mentioned, other types of waste for which national data are not available or are not current are listed below and described in Appendix B. These other types of waste contribute a substantial amount to the total waste "universe," although the exact percentage of the total that they represent is unknown.

Other Types of Waste

Extraction wastes

Industrial non-hazardous waste

Household hazardous waste

Agricultural waste

Construction and demolition waste

Medical waste

Oil and gas waste

Sludge

What is the extent of land used for waste management?

Between 1989 and 2000, the number of municipal landfills in the U.S. decreased substantially—from 8,000 to 2,216.[79] The combined capacity of all landfills, however, remained relatively constant because newer landfills typically have larger capacities. In 2000, municipal landfills received approximately 128 million pounds of MSW, or about 55 percent of what was generated.[80] In addition to municipal landfills, the nation had 18,000 surface impoundments—ponds used to treat, store, or dispose of liquid waste—for non-hazardous industrial waste in 2000.[81]

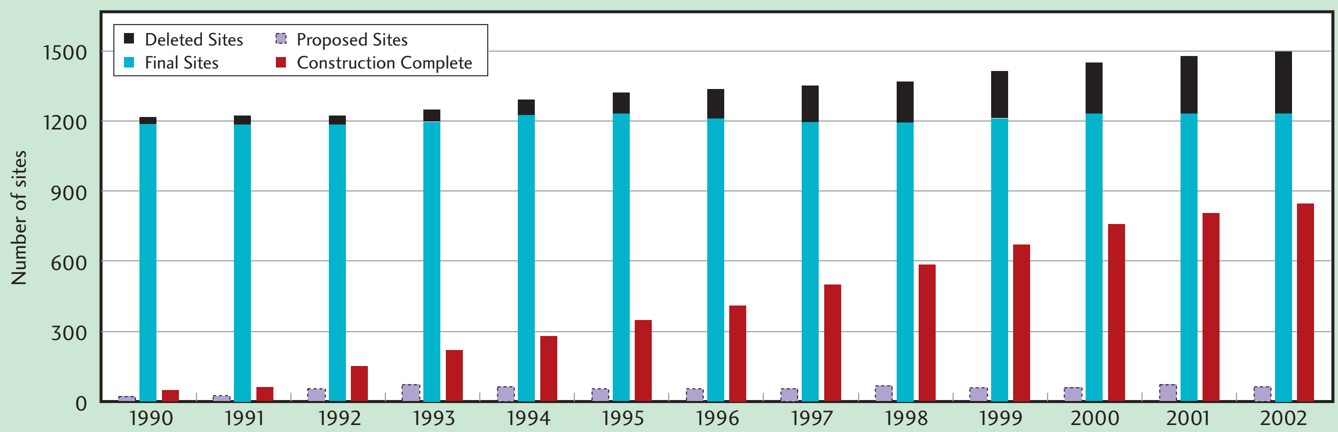
Excluding wastewater, nearly 70 percent of the RCRA hazardous waste generated in 1999 was disposed of at one of the nation's RCRA treatment, storage, and land disposal facilities. Of the 1,575 RCRA facilities, 1,049 are storage-only facilities. The remaining facilities perform one or more of several common management methods (e.g., deepwell/underground injection, metals recovery, incineration, landfill disposal).[82]

The nation also uses other sites for waste management and disposal, but there are no comprehensive data sets that assess those additional sites or the extent of land now used nationally for waste management in general. Before the 1970s, waste was not subjected to today's legal requirements to reduce toxicity before disposal and was typically disposed of in open pits. Early land disposal units that still pose threats to human health and the environment are considered to be contaminated lands and are subject to federal or state cleanup efforts.

What is the extent of contaminated lands?

Many of the contaminated sites that must be managed and cleaned up today are the result of historical contamination. Located throughout the country, contaminated sites vary tremendously. Some sites involve small, non-toxic spills or single leaking tanks, whereas others involve large acreages of potential contamination such as abandoned mine sites. To address the contamination, federal and state programs use a variety of laws and regulations to initiate, implement, and enforce cleanup. The contaminated sites are generally classified according to applicable program authorities, such as RCRA Corrective Action, Superfund, and state cleanup programs.

Exhibit 3-10. Superfund National Priorities List (NPL) site totals by status and milestone, 1990-2002



Note: "Construction Complete" sites include most "Deleted" sites and some "Final" sites.

Source: EPA, Office of Solid Waste and Emergency Response. National Priorities List Site Totals by Status and Milestone. March 26, 2003. (April 3, 2003; *http://www.epa.gov/superfund/sites/query/queryhtm/npltotal.htm*) and Number of NPL Site Actions and Milestones by Fiscal Year. March 26, 2003. (April 3, 2003; *http://www.epa.gov/superfund/sites/query/queryhtm/nplfy/htm*).

Although many states have data about contaminated sites within their boundaries, the total extent of contaminated land in the U.S. is unknown because few data are aggregated for the nation as a whole and acreage estimates are generally not available. A nationally accurate assessment would require both more detailed information on specific sites—such as the area of each site—and consistent aggregation of those data nationally. To assess the full nature of "extent" would require data on specific contaminants, as well as an assessment of risks, hazards, and potential for exposure to those contaminants.

Other Types of Contaminated Lands

Leaking underground storage tanks

Accidental spill sites

Land contaminated with radioactive and other hazardous materials

Brownfields

Some military bases

Waste management sites that were poorly designed or poorly managed

Illegal dumping sites

Abandoned mine lands

The most toxic abandoned waste sites in the nation are listed on the Superfund National Priorities List (NPL) (Exhibit 3-10). Thus, examining the NPL data—along with data on RCRA corrective action sites—provides an indication of the extent of the most significantly contaminated sites. NPL sites are located in every state and several territories. As of October 2002, there were 1,498 final or deleted NPL sites.[83] An additional 62 sites were proposed to the NPL.[84] (When a "proposed" site meets the qualifications to be cleaned up under the Superfund Program, it becomes a final NPL site. Sites are considered for "deletion" from the NPL list when cleanup is complete.) Of the 1,498 sites, 846 sites are "construction completion sites," which are former toxic waste sites where physical construction for all cleanup actions are complete, all immediate threats have been addressed, and all long-term threats are under control. This is up from 149 construction completes in 1992.

EPA also estimates that approximately 3,700 hazardous waste management sites may be subject to RCRA corrective action, which would provide for investigation and cleanup and remediation of releases of hazardous waste and constituents. Contamination at the sites ranges from small spills that require soil cleanup to extensive contamination of soil, sediment, and ground water. In addition, 1,714 of these 3,700 potential corrective action sites are high-priority sites that are targeted for immediate action by federal, state, and local agencies.[85]

Other types of contaminated lands, for which data are very limited, include areas contaminated by leaking underground storage tanks and brownfields. Brownfields are lands on which hazardous substances, pollutants, or contaminants may be or have been present. Brownfields are often found in and around economically depressed neighborhoods. Cleaning up and redeveloping these lands can benefit surrounding communities by reducing health and environmental risks, creating more functional space, and improving economic conditions. The other types of contaminated lands are listed here (see box) and described in more detail in Appendix B.

What human health effects are associated with waste management and contaminated lands?

People who live, work, or are otherwise near contaminated lands and waste management areas are more vulnerable than

Human Exposures Under Control at Identified Contaminated Sites

Progress is being made to control the pathways by which humans are potentially exposed, under current conditions, to unacceptable levels of contaminants at Superfund and priority RCRA Corrective Action sites. In October 2002, 1,199 Superfund sites out of 1,494 Superfund sites were found to have human exposures under control (Exhibit 3-11a).[86] As of March 2003, 1,056 of 1,714 RCRA Corrective Action sites were similarly found to have human exposures under control (Exhibit 3-11b).[87] "Under control" indicates that EPA or state officials have determined that there are no unacceptable human exposures to contamination (present above appropriate risk-based levels) that can be reasonably expected under current land- and water-use conditions. Examples of risk-based levels used in these determinations include EPA- and/or varying state-promulgated standards, as well as other appropriate standards, guidelines, guidance, or criteria.

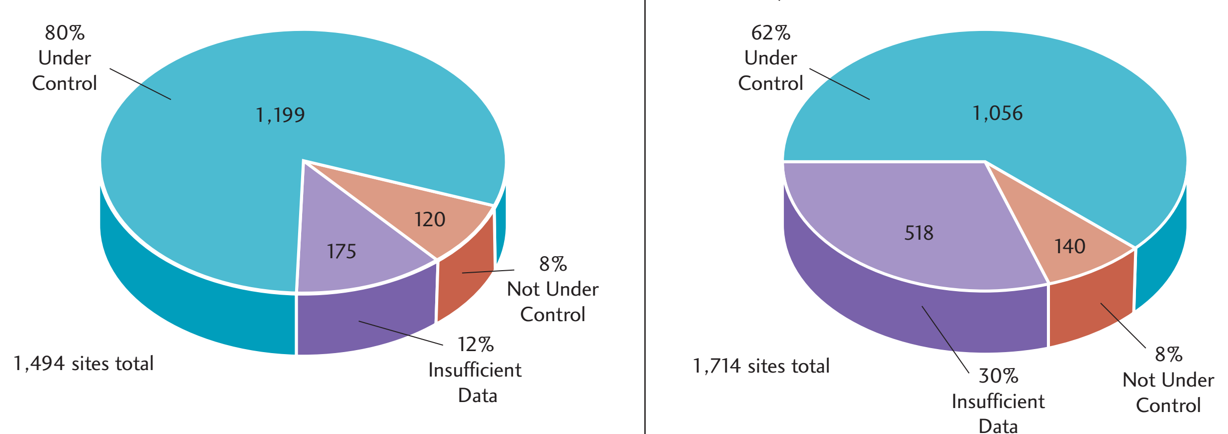
Government officials base a "Current Human Exposures Under Control" determination on site-specific characterization information, including chemical analyses of relevant environmental media (ground water, surface water, indoor and outdoor air, and soil), and on the potential ways people could be exposed to that contamination including inhalation, direct contact, or ingestion of the contaminated media or food impacted by contaminated media. In addition, examples of exposure control actions taken that could lead to an "under control" determination include implementing cleanups such as removing contaminated media, providing alternative water supplies, and implementing access and other land use controls and restrictions. These site-specific evaluations result in an EPA or state official determining that human exposures are either under control, not under control, or that there is insufficient information to make the determination.

It is important to note that the environmental measurements, human activity patterns, and actions taken to prevent exposure are the basis of these human exposures determinations. Biomonitoring or personal monitoring (see Chapter 4 – Human Health) is not typically used to make these determinations. Furthermore, EPA uses "Current Human Exposures Under Control" as a means to measure short-term protectiveness; additional cleanup actions (i.e., beyond those on which the "Current Human Exposures Under Control" is based) may be necessary as part of a final remedy designed to ensure long-term protection from reasonably expected future exposures.

Exhibit 3-11: Human exposure under control at identified hazardous waste sites

a. Human exposure under control at Superfund National Priorities List (NPL) hazardous waste sites

b. Human exposure under control at Resource Conservation and Recovery Act (RCRA) Corrective Action hazardous waste sites



Note: The data used in this display were drawn directly from the CERCLIS database specifically for this report using queries for human exposure. 4 deleted/deferred NPL sites are not included.

Source: EPA, Office of Solid Waste and Emergency Response. *Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) Database.* October 2002.

Note: The data used in this display were drawn from the RCRAInfo database using code CA 725 (Human Exposures Controlled). The results displayed for insufficient data include those facilities that have yet to be evaluated for this determination.

Source: EPA, Office of Solid Waste and Emergency Response. *Facilities on the RCRA GPRA Cleanup Baseline.* March 2003.

Migration of Contaminated Ground Water Under Control at Identified Contaminated Sites

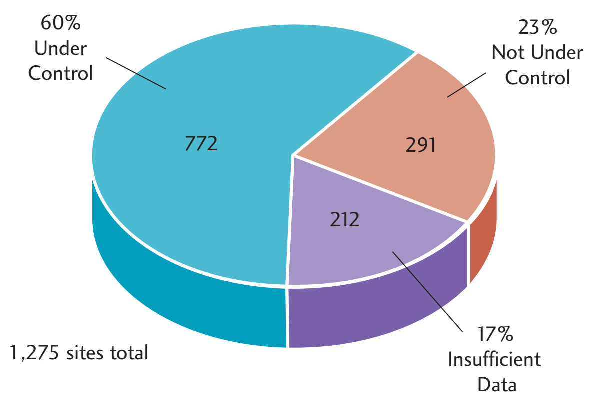
Progress is being made to control the spread of contamination in ground water at Superfund and priority RCRA Corrective Action sites. As of October 2002, 772 out of 1,275 Superfund sites had ground water contamination under control (Exhibit 3-12a).[88] Similarly, as of March 2003, 899 of the 1,714 RCRA Corrective Action sites were under control (Exhibit 3-12b).[89] "Under control" means a plume of contaminated ground water is not spreading above appropriate risk-based levels, or is not adversely affecting surface water bodies into which contaminated ground water is discharging. Examples of risk-based levels used in these determinations include EPA- and/or varying state-promulgated standards, as well as other appropriate standards, guidelines, guidance, or criteria.

Government officials base a "Migration of Contaminated Ground Water Under Control" determination on site-specific characterization information and monitoring data pertaining to relevant environmental media (e.g., ground water and surface water where warranted). In addition, examples of actions taken that could lead to an "under control" determination include documenting the lack of plume growth in response to an engineered "pump and treat" or subsurface barrier system, or in response to natural attenuation processes (both of which would include ongoing monitoring). These site-specific evaluations result in an EPA or state official determining that the migration of contaminated ground water is under control, not under control, or that there is insufficient information to make the determination.

EPA is using the "Migration of Contaminated Ground Water Under Control" determination as a means of protecting ground water and surface water resources. As such, actual or potential human exposures to contaminants in ground water would be addressed in the "Current Human Exposures Under Control" determination. Furthermore, "Migration of Contaminated Ground Water Under Control" is a short-term cleanup goal; additional cleanup actions (i.e., beyond those on which this measure is based) may be necessary as part of a final remedy designed to ensure long-term protection of ground water resources.

Exhibit 3-12: Contaminated ground water migration under control at identified hazardous waste sites

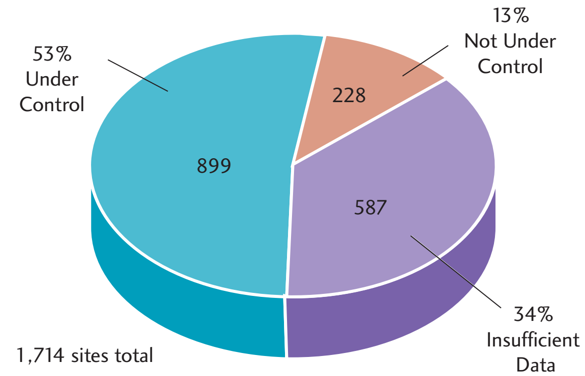
a. Contaminated ground water migration under control at Superfund National Priorities List (NPL) hazardous waste sites



Note: The data used in this display were drawn directly from the CERCLIS database specifically for this report using queries for ground water migration.

Source: EPA, Office of Solid Waste and Emergency Response. *Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) Database.* October 2002.

b. Contaminated ground water migration under control at Resource Conservation and Recovery Act (RCRA) Corrective Action hazardous waste sites



Note: The data used in this display were drawn from the RCRAInfo database using code CA 750 (Migration of Contaminated Groundwater Controlled). The results displayed for insufficient data include those facilities that have yet to be evaluated for this determination.

Source: EPA, Office of Solid Waste and Emergency Response. *Facilities on the RCRA GPRA Cleanup Baseline.* March 2003.

others to the threats such areas might pose in the event of accident or unintended exposure to hazardous materials. Depending on factors such as management practices, the sources of contamination, and potential exposure, some waste, contaminated lands, and lands used for waste management pose a much greater risk to human health than others. Some areas, such as properly designed and managed waste management facilities, pose minimal risks.

Determining the relationship between types of sites and human health is usually extremely complicated. For many types of cancer, understanding is limited by science and the fact that people usually are exposed to many possible cancer-causing substances throughout their lives. Isolating the contributions of exposure to contaminants to incidence of respiratory illness, cancer, and birth defects is extremely difficult—impossible in many cases. Nonetheless, it is important to gain a more concrete understanding of how the hazardous materials associated with waste and contaminated lands affect human populations.

Although some types of potential contaminants and waste are not generally hazardous to humans, other types can pose dangers to health if people are exposed. The number of substances that exist that can or do affect human health is unknown; however, the TRI program requires reporting of more than 650 chemicals and chemical categories that are known to be toxic to humans.

EPA's Superfund Program has identified several sources of common contaminants, including commercial solvents, dry-cleaning agents, and chemicals. With chronic exposure, commercial solvents such as benzene may suppress bone marrow function, causing blood changes. Dry-cleaning agents and degreasers contain trichloroethane and trichloroethylene, which can cause fatigue, depression of the central nervous system, kidney changes (e.g., swelling, anemia), and liver changes (e.g., enlargement).[90] Chemicals used in commercial and industrial manufacturing processes, such as arsenic, beryllium, cadmium, chromium, lead, and mercury, may cause various health problems. Long-term exposure to lead may cause permanent kidney and brain damage. Cadmium can cause kidney and lung disease. Chromium, beryllium, arsenic, and cadmium have been implicated as human carcinogens.[91]

What ecological effects are associated with waste management and contaminated lands?

Hazardous substances, whether present in waste, on lands used for waste management, or on contaminated land, can harm wildlife (e.g., cause major reproductive complications), destroy vegetation, contaminate air and water, and limit the ability of an ecosystem to survive. For example, if not properly managed, toxic residues left from mining operations can be blown into nearby areas, affecting resident bird populations and the water on which they depend. Certain hazardous substances also have the potential to explode or cause fires, threatening both wildlife and human populations.[92]

The negative effects of land contamination and occasionally of waste management on ecosystems occur after contaminants have been released on land (soil/sediment) or into the air or water. For example, mining activities have affected aquatic life in Colorado's Eagle River, as described in box, "Cleanup of the Eagle Mine Superfund Site."

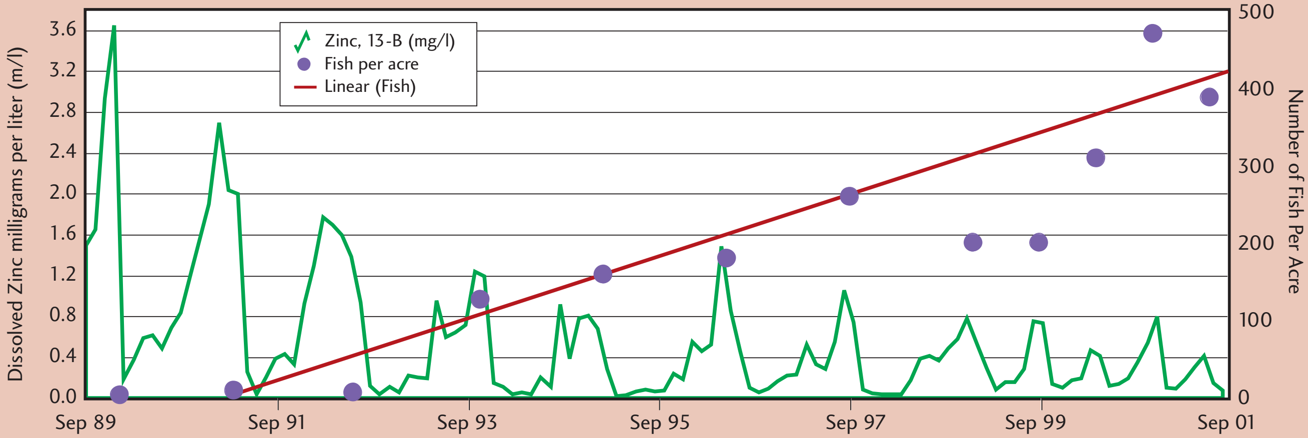
Cleanup of the Eagle Mine Superfund Site

The Eagle Mine, southwest of Vail, Colorado, was used to mine gold, silver, lead, zinc, and copper between 1870 and 1984. After the mine closed, several contaminants, including lead, zinc, cadmium, arsenic, and manganese, were left behind, and they spread into nearby ground water, the Eagle River, and the air, posing a risk to people and wildlife.

Colorado filed notice and claim in 1985 against the former mine owners for natural resource damages under Superfund. In June 1986, the site was placed on the National Priority List, and shortly thereafter the state and the previous owners agreed to a plan of action. Cleanup operations included constructing a water treatment plant to collect mine seepage and other contaminated water sources; relocating all processed mine wastes and contaminated soils to one main, on-site tailings pile; capping that pile with a multilayer clean soil cap; and revegetating all disturbed areas with native plant species.

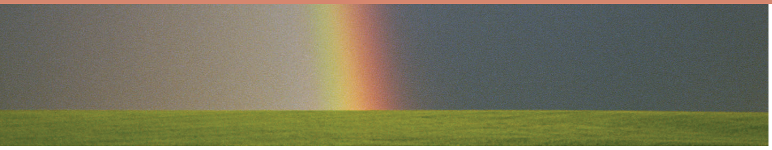
The water quality in the Eagle River began to show improvements in 1991; as zinc concentrations in the river dropped, the resident brown trout population grew (Exhibit 3-13). An October 2000 site review concluded that public health risks had been removed and that significant progress had been made in restoring the Eagle River. Today, biological monitoring is undertaken to sample the Eagle River's water quality, aquatic insects, and fish populations.[93]

Exhibit 3-13: Eagle mine zinc concentrations and brown trout populations downstream of the consolidated tailings pile



Note: Zinc concentrations fluctuate during the seasons according to water levels.

Source: Colorado Department of Public Health and Environment, Hazardous Materials and Waste Management Division. Eagle Mine. February 5, 2003. (April 7, 2003; *http://www.cdphe.state.co.us/hm/rpeagle.asp#SiteSummary*).



Limitations of Land Indicators

Many sources of data support indicators that help to answer questions about the trends and effects of land use, chemicals in the landscape, and waste and contaminated land. But there are limitations in using the indicators to fully answer the questions.

Land Use

There are a number of gaps in information about land use and cover. Significantly varying estimates of developed land result from varying definitions and approaches to land use assessments. Statistical sampling and satellite remote sensing techniques vary in total estimates—and represent different sources of error. Data on some cover types and land uses are sparse or nonexistent, and inventories are seldom done on lands in Alaska. Numerous federal agencies conduct national inventories, but because they cover different land areas with different classifications and varying statistical sampling, integrating those data is challenging. Remotely sensed data are being used increasingly to estimate land cover but will probably need to be combined with other data sets to produce an accurate estimate of land uses. Additionally, remote sensing data from multiple years are not readily available for analysis of trends. Soil erosion information is collected by the NRI for croplands but does not exist nationally for forests or rangelands, particularly those under federal ownership.

Chemicals in the Landscape

No pesticide reporting system currently provides information on the volume, distribution, and extent of pesticide use nationwide across all sectors. Data used in this report are only estimates based on available information that includes crop profiles, pesticide sales, expert surveys, and sampling of stream and ground water. While no national reporting system exists, California has developed an advanced system for full pesticide use reporting. Reports about the specifics of pesticide applications are filed by farmers, commercial applicators, structural pest control companies, and commercial landscaping firms.[94]

The TRI program does not cover all releases of chemicals from all industrial facilities. For example, facilities that do not meet the TRI reporting requirements (those that have fewer than 10 full-time employees or do not meet TRI chemical-specific threshold amounts for reporting) are not required to report their releases. Some facilities conduct and report on actual monitoring data; others use estimation approaches, which are not consistent nationwide. New chemicals are being produced constantly, which poses challenges to EPA's efforts to monitor their potential interaction and effects.

Better information is needed on the chemistry, quantities, and longevity of various substances; on the cumulative effects of various chemicals on the environment and humans; and on the pathways and effects of exposure. More monitoring is required, along with more effective means to link ambient exposures to health and ecological effects. A more comprehensive and cohesive intergovernmental—federal, state, and local—reporting system that helps to link environmental and health data would be of great assistance.

Waste and Contaminated Lands

The data available nationally on total waste generated are not comprehensive; they exist as independent data sets maintained by different agencies and organizations. The data are gathered in various units (e.g., MSW in weight by pounds or tons, radioactive waste in volume by canisters). No easy method exists to convert weight to volume for understanding "extent."

Some data are available on sites used for various types of waste management, but there is no broad assessment or national database of contaminated lands. National-level statistics on the total acreage of those lands, actual concentrations found in soils or waters around the sites, or health or ecological effects around the sites do not exist. Lack of those data creates challenges for addressing cleanup or redevelopment opportunities.

In lieu of national-level environmental indicators, activity measures of prevention, reduction of toxicity, and cleanup are used as indicators. Those measures take into account health and ecological outcomes. At this time, they are the best available indicators of environmental status and effects.

Endnotes

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[4] Ibid.

[5] Alaska Department of Natural Resources. Fact Sheet: Land Ownership in Alaska. March 2000. (September 2002; *http://www.dnr.state.ak.us/mlw/factsht/land_own.pdf*).

[6] Ibid.

[7] U.S. Department of Agriculture, Natural Resources Conservation Service. *America's Private Land: A Geography of Hope,* Washington, DC: U.S. Department of Agriculture, June 1997.

[8] U.S. General Services Administration. *Summary report on real property owned by the United States throughout the world,* 1999. op. cit.

[9] Wilderness Information Network. National wilderness preservation system database. August 2002. (February 10, 2003; *http://www.wilderness.net/nwps*).

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[14] U.S. Department of Agriculture, Natural Resources Conservation Service. 1997 National Resources Inventory Highlights. January 2001. (February 2003; *http://www.nrcs.usda.gov/technical/land/pubs/97highlights.pdf*).

[15] Ibid.

[16] U.S. Department of Agriculture, Natural Resources Conservation Service. *Summary Report: 1997 National Resources Inventory* (*Revised December 2000*), 2000. op. cit.

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